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Edie Starbuck, a geologist with the Department of Natural Resources, uses a PC tablet and GPS as she collects data in the field.

GEOLOGIC MAPS

Essential tools in planning Missouri's future

Often colorful and visually appealing, geologic maps may be one of Missouri's best but most overlooked planning tools. Earth scientists realize that these maps are the fundamental source of geologic information, but geologists are not the only users. Geologic maps are a public resource of broad value to our society. Understanding the earth beneath our feet is the first step in understanding the world around us. Foresters and biologists are aware that geologic conditions affect ecology. Engineers are concerned with the properties of soil and bedrock along proposed highway construction. City planners want to know about the likelihood of damage from earthquakes, landslides or sinkhole collapse on infrastructure such as pipelines, roads and wastewater and drinking water facilities. Geologic mapping provides the basic information we need about many of our finite natural resources. The potential impact on Missouri's economy is staggering. According to one study, the value of geologic maps is 25 to 39 times the cost of producing them. Geologic maps are essential to planning Missouri's future because they help us optimize the use of water, fuel and mineral resources and minimize environmental degradation and hazards.

MISSOURI
DEPARTMENT OF NATURAL RESOURCES
Division of Geology and Land Survey

Data Collection and Field Investigation

To collect data for a geologic map, geologists investigate existing data including logs of wells that have been drilled in the area, descriptions of exposures, or “outcrops,” that were previously examined, along with existing mapping. They also examine available aerial imagery to look for linear trends or variations in topography or vegetation that may be a clue to the underlying geology. However, most of the data collected for a new bedrock map comes from field investigation. Geologists investigate by inspecting features along roads, ditches, streams, quarries, bluff lines and hillsides to find exposures of bedrock and surficial materials. Loose rock, soil, and even vegetation, can be clues to underlying materials. Geologists try to locate a large number of data points that are evenly distributed. This requires the cooperation of landowners who allow access to their property. Data is collected along roads and on public property, but in many parts of the state, most of the property is owned privately and the cooperation of landowners contributes greatly to the effort to collect data.

As investigations proceed, the geologist will take notes about the rock type (lithology), fossils (paleontology) and about the particular sequence of layers (stratigraphy). To create a map at a scale of 1:24,000, the division’s mappers attempt to collect at least 11 data points per square mile, or about 660 data points per 7.5 minute quadrangle. A geologist will walk 50 to 100 miles collecting data during a field season to prepare a geologic map for one 7.5 minute area.

DNR photo by Mike Siemens

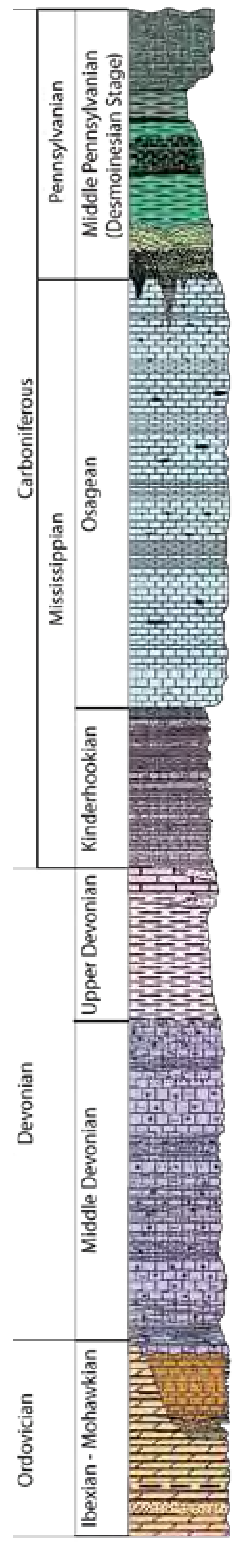
DNR geologist, Chris Vierrether, collecting data along a bluff near Gasconade, Missouri. The bluff contains St. Peter sandstone laid down by a tropical ocean some 470 million years ago.

Map Development

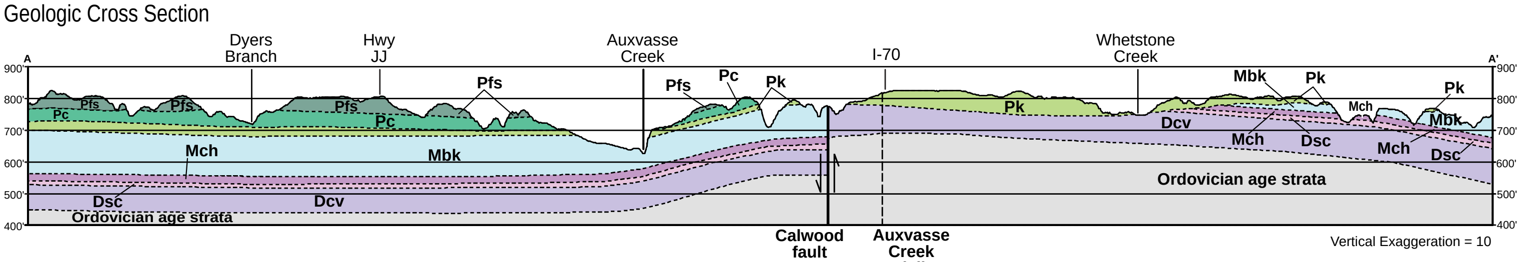
Once the geologist returns to the office, the data must be interpreted and summarized. This is done by producing a map of the distribution of geologic units, describing each unit and drawing a stratigraphic column for the bedrock maps. Geologic unit boundaries are printed on top of U.S. Geological Survey topographic maps of the area to help orient the user. A topographic map is a detailed and accurate graphic representation of some of the cultural and natural features on the ground. The base map is printed with light colors, so it doesn’t interfere with seeing the geologic features on the map. A stratigraphic column and unit description help users to interpret the map. The stratigraphic column displays the layering of each unit as well as its thickness and relationship to other units. The color of each unit on the stratigraphic column corresponds with the color of the unit on the map. Letter symbols are used to abbreviate the unit on the map and the description.

The geologist also interprets the bedrock structures such as faulting and folding of bedrock. These structures are formed when earth forces cause layers to bend or break. Faulting can be an indicator of the likelihood of an earthquake, but often these features were formed hundreds of millions of years ago, and the area may no longer be a site of earthquake activity. Faulting and folding of bedrock has an effect on the present-day flow of groundwater and the distribution of mineral resources. Most bedrock geologic maps include a description of the bedrock structures indicating the location and nature of the structure. The description will note whether the structure is a fault or fold, and how far the bedrock layers may be offset if there is faulting. Bedrock structures are also represented in a graphic form as a geologic cross section. A geologic cross section shows what a vertical slice through the earth would look like along a given line.

Partial Stratigraphic Column



Geologic Cross Section



A Moment in Time

Early years of geologic mapping in Missouri

The "Geological Map of the South-west Branch, Pacific Rail Road" was published in 1859 along with a report on the same subject. This investigation was performed prior to completion of the rail line. George C. Swallow, the author of the report, was the first Missouri State Geologist and chief administrator of the first Missouri Geological Survey. The duties of this agency were later passed on to the Geological Survey Program, within the Division of Geology and Land Survey. This map is on display at the division's Buehler Building at 111 Fairgrounds Road, in Rolla

Geologic Maps Matter

Many types of maps and geologic studies are based on geologic maps. Evaluations of mineral resources are needed to determine the availability of stone for road construction, metals for buildings and cars, and oil or coal for fuel. Simply put, these types of studies require geologic maps. The type of earth material beneath our feet determines our susceptibility to geologic hazards such as sinkhole collapse, landslides or earthquake damage. Geologic hazard maps benefit society by providing the information necessary to make decisions about construction and infrastructure design in earthquake-prone areas. Many people are interested in geologic maps simply because they want to know more about the rocks or fossils that they see on their property, or they may want to know where to look to find certain types of minerals or fossils to collect. Geologic maps have many uses and are an important resource for Missourians with varied needs and interests.

Uses of Geologic Mapping

- Exploring for and developing mineral, fuel and water resources
- Cleaning up environmentally damaged sites
- Avoiding karst, earthquake and landslide hazards
- Designing foundations and structures
- Making zoning and city planning decisions
- Locating waste disposal facilities
- Siting landfills and liquid waste treatment facilities
- Evaluating property
- Planning transportation
- Delineating ecosystems

Requests for Geologic Mapping at Groundwater Contamination Sites


DNR photo by Scott Myers

Bedrock geologic maps are essential to the investigation into the impact of contaminant spills on groundwater supplies. The movement of groundwater (and contaminants) is affected by both bedrock properties and by geologic structures. Fluids travel more easily through some types of rock than others. For example, shale normally presents a barrier to fluid movement, and water will flow differently through limestone than it does through sandstone. Bedrock fracturing associated with folding and faulting, often provides pathways through which contaminants can migrate. For these reasons, division geologists are sometimes requested to do geologic mapping in locations of ongoing groundwater contamination investigations.

The department's Environmental Quality division requested that Geological Survey staff conduct a detailed geologic investigation of the Oak Grove Village and Sullivan areas as part of the investigation into contamination of a public water supply well. This investigation, along with a hydrologic investigation conducted by staff with the division's Environmental Geology section, indicated that deep groundwater flows along the trend of bedrock folding that is in the area. Solution channels or small connected voids have also developed in the soluble dolomite bedrock, allowing shallow groundwater to flow from one surface water drainage basin to another. A similar investigation was conducted as part of a remedial investigation funded by the U.S. Environmental Protection Agency into the contamination of water wells at New Haven. As a result of this collaborative effort, it was determined that the direction of groundwater movement parallels the slope of bedding plane surfaces. Structures that may affect groundwater movement were also discovered. This type of information allows researchers to track the source of contamination and determine where it has spread.

The Geologic Mapping Advisory Committee and STATEMAP

The National Cooperative Geologic Mapping Program (NCGMP) was mandated with the National Geologic Mapping Act of 1992 because of the need for a comprehensive nationwide program of detailed geologic mapping. The NCGMP, developed and coordinated by the U.S. Geological Survey and the Association of American State Geologists, annually receives federal funds which it disperses through a competitive project proposal process. STATEMAP is the component of the NCGMP that provides funds to state geological surveys for geologic mapping. The Division of Geology and Land Survey is Missouri's state geological survey. States receiving STATEMAP funding provide matching funds. One requirement is that geologic mapping priorities are set in consultation with a panel of individuals across the state, having varied interests in geologic mapping. This group comprises the Geologic Mapping Advisory Committee (GMAC).

Members of Missouri's GMAC serve three-year terms and may serve no more than three consecutive terms. All ten members were new to the committee in 2007. The membership encompasses several different constituencies of bedrock map users. This group includes geological consultants, mining and energy interests, development planners, geologic hazard experts, academia and a representative of a professional geological society. The committee meets annually to direct plans for detailed geologic mapping in Missouri.

Map Scale

Scale determines how much information a map can display. Scale is the ratio of the length of a feature depicted on the map, compared to the length of the actual feature. For instance, a map scale of 1:24,000 means that one inch on the map represents 24,000 inches (2,000 feet) in the real world. If your house is 2,000 feet from a road intersection, then that distance is only one inch on a map of that scale. When a map's scale is 1:500,000, then one inch on the map is representative of 500,000 inches in the real world. There are 63,360 inches in a mile, so one inch on the map represents almost eight miles. Consequently, a 1:500,000 scale map cannot display the same detail as a 1:24,000 scale map.

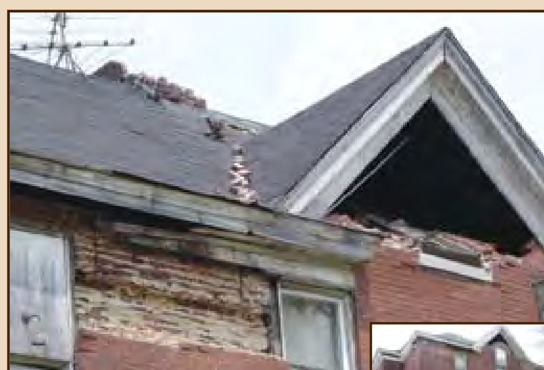
A great amount of confusion is caused by the terms, "small scale" and "large scale" map. Small scale maps show less detail than large scale maps. 500,000 is a big number, but the ratio 1/500,000 is a very small number. Small scale maps show large areas with little detail. Large scale maps show smaller areas, but with more detail. The most detailed topographic maps that are available for the entire state are 1:24,000 scale produced by the U.S. Geological Survey. These maps are often called 7.5 minute quadrangle maps since they cover an area that is 7.5 minutes of longitude by 7.5 minutes of latitude. In Missouri, this is an area that is about 6.5 miles in the east-west direction by 8.5 miles in the north-south direction. These maps appear rectangular, hence the use of the word "quadrangle" to describe them. The Division of Geology and Land Survey makes these maps available for sale. Corresponding geologic quadrangles are also available for purchase. Check out our Web site (www.dnr.mo.gov/geology/adm/publications/topoquads.htm).

Geologic Hazards

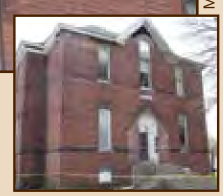
The Importance of Planning

On April 18, 2008 a magnitude 5.2 earthquake with an epicenter in southern Illinois shook a large area of the Midwest, including much of eastern Missouri. About two weeks later, on May 5, a magnitude 2.7 earthquake centered near Valley Park rattled Missourians again. Though these quakes caused no major damage, Missourians were left wondering, "When is the next one?" Actually, small earthquakes occur in Missouri fairly frequently. In the first half of 2008, 124 earthquakes with a magnitude less than three occurred in southeastern Missouri. Most are so small that no one feels them. The occurrence of larger quakes reminds Missourians that our history includes the massive earthquakes of 1811 and 1812. Important tools that can be used to prepare for the repeat of such a disastrous event are earthquake hazard maps. Earthquake hazard depends on the location, magnitude and frequency of likely earthquakes and on the properties of the rocks and sediments through which earthquake waves travel. Information about the properties of rocks and sediments in an earthquake-prone area comes from basic geologic mapping.

Other geologic hazards can also be defined by geologic mapping. The risk of sinkhole development is based primarily on the presence of limestone or dolomite, the degree of weathering and the surficial materials present. Landslides in Missouri are also related to geologic conditions. Geologic maps are routinely used to evaluate proposed sewage lagoon sites for catastrophic collapse potential.



Mary Seid, Illinois Geological Survey



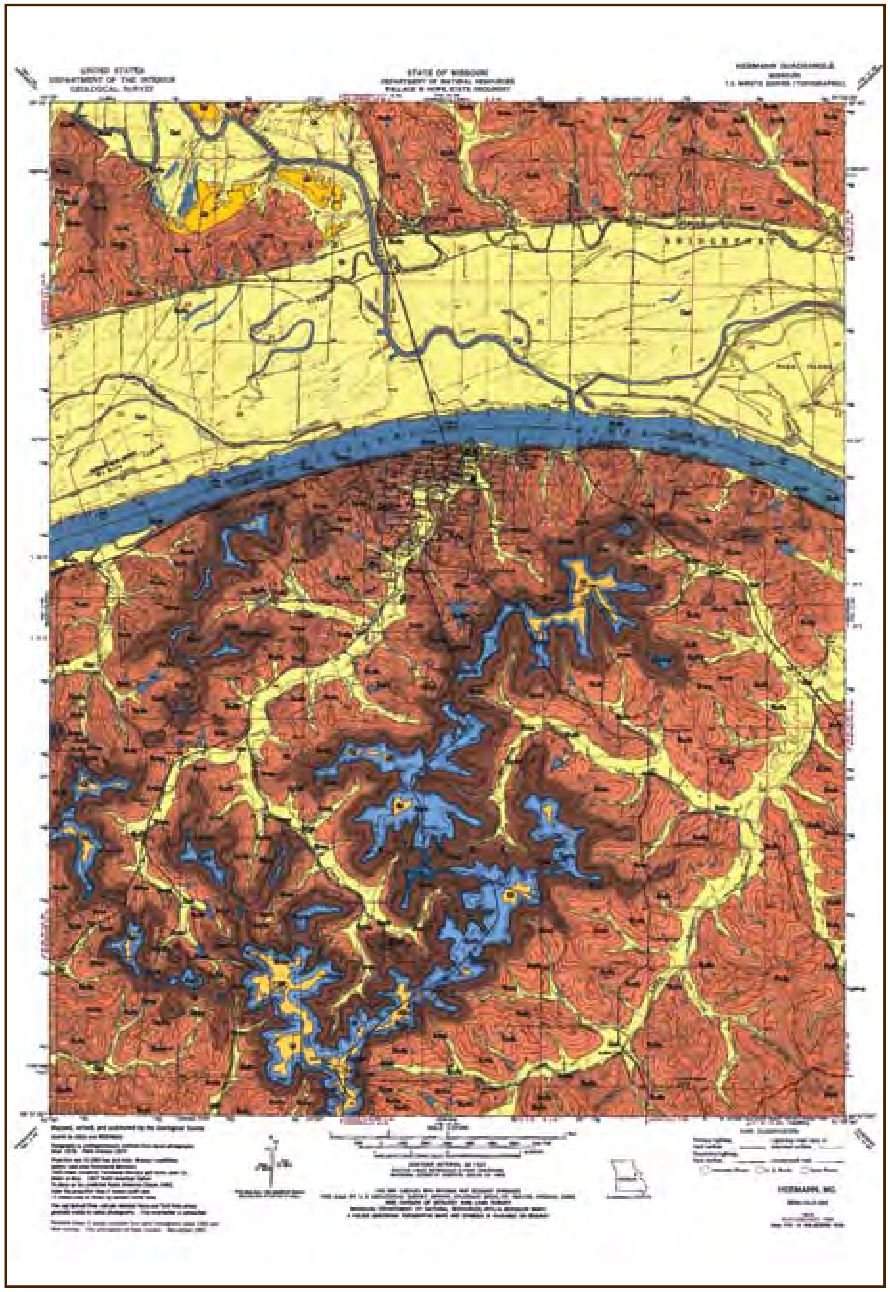
A wider view of the 1904 Berry School, Mt. Carmel, Illinois, shows the collapsed chimney, bricks missing from the wall, and bricks missing from the A-frame.

Web Sites

Geologic Maps
www.dnr.mo.gov/geology/statemap/missouri-maps.htm
GMAC Web Page
www.dnr.mo.gov/geology/geosrv/gmac/
STATEMAP Fact Sheet
www.dnr.mo.gov/geology/geosrv/Missouri.pdf
Geologic Hazards Web Page
www.dnr.mo.gov/geology/geosrv/geores/GeoHazhp.htm
Publications Catalog
www.dnr.mo.gov/geology/adm/publications/pubscatalog.pdf

Available in Various Formats

Geologic maps are available to the public in different formats. Some of the maps have been published and printed on paper. They are waiting on our shelves to be sold. Many of our maps are stored as electronic image files and can be plotted on paper when a customer needs them, or copied to a CD-ROM. All of the bedrock maps that the division has published since 1997 were created using a geographic information system (GIS). The electronic files in a GIS are spatially referenced (linked to location) so that the information can easily be compared to other data in the same or a nearby location. The digital bedrock geologic map of Missouri based on the 1:500,000 scale Sesquicentennial map, is available in a GIS compatible format. Approximately 104 of the more than 1,300 quadrangles in Missouri have been mapped in a GIS format at a scale of 1:24,000. Most of these have been incorporated into the digital geologic map of Missouri.



This is scaled-down image of a 1:24,000 scale surficial material map. The area shown includes the city of Hermann and includes parts of the counties of Gasconade, Montgomery and Warren. When printed, the complete map is 36" x 44" and includes descriptive text, a legend, stratigraphic column and cross section illustrations.

Bedrock or Surficial?

Different maps are produced for different uses. Bedrock geologic maps provide information about the layering of bedrock units and faulting, folding or deformation that may be present. Bedrock maps provide information about the distribution and structure of consolidated rock such as limestone, sandstone, coal and granite. Surficial material maps focus on all of the deposits above bedrock. This includes soil, but it also includes up to several hundred feet of deeper unconsolidated material. Surficial materials geologic maps indicate the distribution of materials such as residuum, till and alluvium.

Publications

Early geologic reports are still useful to researchers, but until recently many were not readily available to the public, some are out of print and others difficult to find in libraries. The Division of Geology and Land Survey recently completed a comprehensive project of electronically scanning and cataloging these documents in an effort to preserve them and to make them more accessible. As a result, many of out-of-print publications are available again, in CD-ROM format. Examples of out-of-print publications that are now available include:

Report of a Geological Reconnaissance of that Part of the State of Missouri Adjacent to the Osage River, made to William H. Morrell, Chief Engineer of the State, by Order of the Board of Internal Improvement, by Henry King, M.D., Geologist, in Senate Journal Appendix, 1st Session, Missouri 11th General Assembly, p. 506-535, Jefferson City, 1840.

Geological report of the South-western Branch of the Pacific Rail Road, State of Missouri, by G.C. Swallow, 110 p., 2 pls., folded map, 1859.

Preliminary Report on the Iron Ores and Coal Fields from the Field Work of 1872, by Raphael Pumpelly, Adolph Schmidt, G.C. Broadhead, and W.B. Potter, 671 p., 190 illus., and atlas with 14 large sheets, 1873.

Geology of the Disseminated Lead Deposits of St. Francois and Washington Counties, by Ernest Robertson Buckley, pt. 1, 275 p., pls. 1-39, 10 figs., pt. 2, pls. 40-121, including geologic map of southeastern Missouri, 1908.

The Oil and Gas Resources of Cass and Jackson Counties Missouri, by Joseph R. Clair, 208 p., 7 pls., 14 figs., 1 tbl., 1943.

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New Geologic Maps

OFM-07-523-GS Bedrock geologic map of the Fulton 7½' quadrangle, Callaway County, Missouri by Mark A. Middendorf, 2007, scale 1:24,000.

OFM-07-524-GS Surficial material geologic map of the Fulton 7½' quadrangle, Callaway County, Missouri by Mike Chalfant, Wyn Kelley and Mike Siemens, 2007, scale 1:24,000.

OFM-07-525-GS Bedrock geologic map of the Readsville 7½' quadrangle, Callaway and Montgomery counties, Missouri by Edith A. Starbuck, 2007, scale 1:24,000.

OFM-07-526-GS Surficial material geologic map of the Readsville 7½' quadrangle, Callaway and Montgomery counties, Missouri by Mike Chalfant, Wyn Kelley and Mike Siemens, 2007, scale 1:24,000.

OFM-07-527-GS Bedrock geologic map of the Williamsburg 7½' quadrangle, Callaway and Montgomery counties, Missouri by Christopher B. Vierrether, 2007, scale 1:24,000.

OFM-07-528-GS Surficial material geologic map of the Williamsburg 7½' quadrangle, Callaway and Montgomery counties, Missouri by Mike Chalfant, Wyn Kelley and Mike Siemens, 2007, scale 1:24,000.

OFM-07-529-GS Pre-mining Mulberry coal thickness and overburden thickness, Amoret 7½' quadrangle, Bates County, Missouri by Scott Kaden, Lacy Moore and Michael Hill, 2007, scale 1:24,000.

These and other publications may be purchased from the Missouri Department of Natural Resources' Division of Geology and Land Survey. To order, contact the publications desk at: 573-368-2125 or 1-800-361-4827, or use our online form at: www.dnr.mo.gov/geology/adm/publications/MapsOrder.htm. For additional information visit our Web site: www.dnr.mo.gov/geology/.

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